

Testing for the effect of detritus stabilimenta on foraging success in *Cyclosa octotuberculata* (Araneae: Araneidae)

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Abstract — This study tested the possibility that detritus stabilimenta of *Cyclosa octotuberculata* affect prey capture rate. Field experiments showed that there was no significant difference in prey capture rate between webs with and without detritus stabilimenta even after controlling for factors likely to affect foraging success. Thus, detritus stabilimenta appear to have no visual effects on insect prey despite their conspicuous appearance.

Key words — web, visibility, prey capture

Introduction

Some members of the genus *Cyclosa* (Araneidae) decorate orb webs with debris, prey remains and molted exoskeletons (Nakahira 1965). These decorations are called 'detritus stabilimenta' (Rovner 1976), whose form and usage frequency are different among species (Nakahira 1965). *Cyclosa* spiders usually sit among detritus stabilimenta. This behavior obscures spider outline because *Cyclosa* spiders look like a part of detritus stabilimenta. Therefore detritus stabilimenta have been considered to serve as camouflage to defend spiders from predators (Edmunds 1974). There is possibility that detritus stabilimenta have also effects on prey capture rate, because they are large decoration on orb web and they may provide some visual effects for prey insects.

To test this hypothesis, using a species, *Cyclosa octotuberculata* Karsch 1879, I set webs with and without detritus stabilimenta in the field and analyzed prey capture success.

Methods

Cyclosa octotuberculata is one of the commonest *Cyclosa* spiders in Japan. The body length of mature females is approximately 10–14 mm and that of males is 7–8 mm.

Adult females were collected in Nokonoshima Island, Fukuoka Prefecture, western Japan in June and July 2001. I released 10 spiders with similar body size into a laboratory to make them construct orb webs. Most spiders constructed new orb webs on the following day. I chose two orb webs with a similar web area, and fixed each web to a wooden frame having inner area of 670 × 600 mm with adhesive

tape. Each framed web had a spider that had constructed the web.

I measured the following parameters: 1) vertical and horizontal diameters of the web (mm), 2) spiral mesh size (mm), and 3) body length (cephalothorax-abdomen length, mm). Web area S (mm²) was calculated from the following formula, $S = a \times b \times 0.25 \times \pi$ where a and b are vertical and horizontal diameters of the orb web, respectively. Mesh size was expressed as the reciprocal of the number of spiral threads per 10 mm radial thread averaged over 4 directions (upper, lower, left, and right directions from the hub).

Detritus stabilimentum collected from the field was attached carefully to one of the two framed webs by using tweezers. Although the spider moved around detritus stabilimentum for a second immediately after the treatment, it sit motionless at the hub thereafter.

Field experiment was conducted in an open field where tall goldenrod *Solidago altissima* (Asteraceae) dominated. The two framed webs were hung on a wire fence in the field at a height of 155–170 cm above the ground. Each web was set about 1 m apart, facing the same direction. Orb web was gradually destroyed with time by physical damages such as prey contact and wind. To minimize these effects, the experiment was conducted during the daytime between 9:00 and 13:00, which was defined as one experimental trial. I conducted 14 trials from June 7 to July 24, 2001. Positions of webs (right or left) with and without stabilimentum were determined randomly in every trial, which were allocated to following frequency, left: right = 8: 6.

In each trial, I observed the two webs continuously keeping about 2–3 m distance from them. All the prey captured by webs were carefully collected using tweezers, kept in 75% ethanol, and identified prey orders. Because time

spent for collecting prey was only a small fraction of the total observation time, it does not seem to affect prey capture by the webs.

Large insects such as wasps *Polistes* spp. and a cerambycid beetle *Paraglenea fortunei* were removed from the analysis because they were so large that they could not be the potential prey for spiders. Nymphs of a hemipteran bug *Riptortus clavatus* (Alydidae) and ants were also excluded from the analysis, because they were crawling insects whose probability of being captured by the web is unlikely to be affected by the web decoration.

Background light level that is known to affect web visibility (Craig 1990) was measured by illumination photometer. Its acceptance unit was kept parallel to web plane keeping 10 cm distance from it.

Analysis

Wilcoxon's signed rank test was performed to compare the number of prey captured per hour by webs with and without a detritus stabilimentum. This analysis did not consider other factors which are likely to affect prey capture, i.e. web area, mesh size, body length, and background light level. To remove these confounding effects, multiple regression analysis was performed. The existence of detritus stabilimentum and four parameters (web area, mesh size, body length, and background light level) were used as independent variables and the number of prey captured was used as a dependent variable. The existence of detritus stabilimentum was expressed by a dummy variable.

To remove the effect of days of experiment, all variables were expressed as the difference of parameters of webs or spiders with and without a detritus stabilimentum on a given day. Following the method of independent contrast (Harvey & Pagel 1991), multiple regression analysis going through the origin (i.e. zero intercept) was adopted. I used backward elimination method for selecting significant variables.

Because the visual effect of detritus stabilimenta on prey capture rate might differ among taxonomic groups of prey, I performed multiple regression analysis separately for each insect order. The significance level in these analyses was corrected to 0.01 following sequential Bonferroni methods (Sokal & Rohlf 1995) due to five tests (five insect orders).

Results

A total of 227 prey was collected from two types of webs combined. The main prey was Diptera ($n=149$), followed by Hymenoptera ($n=32$) and Hemiptera ($n=25$).

Figure 1 shows differences in the prey capture rates between webs with and without a detritus stabilimentum. There were no significant differences in all cases (Total prey, $Z = -0.315$, $p > 0.05$; Diptera, $Z = -0.314$, $p > 0.05$; Hemiptera, $Z = -0.593$, $p > 0.05$; Hymenoptera, $Z = -0.118$, $p > 0.05$; Others, $Z = -0.154$, $p > 0.05$).

Multiple regression analyses showed that none of the independent variables significantly explained variations in prey capture rate for all prey insects combined as well as for

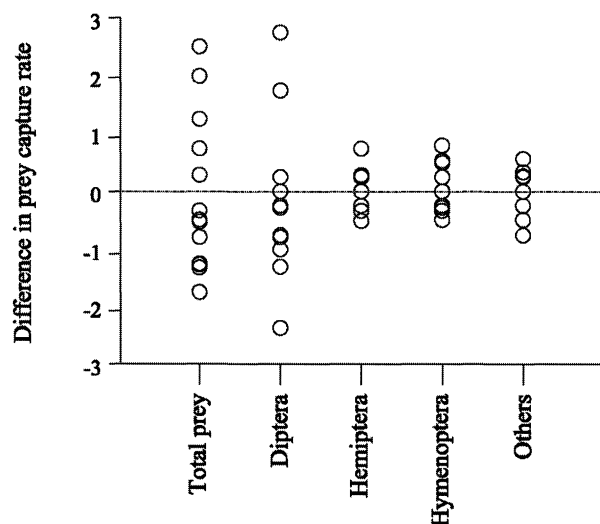


Fig. 1. Differences in prey capture rates per 1 hour between webs decorated with and without a detritus stabilimentum. Each plot represents prey capture rate in a decorated web subtracted by that in an undecorated web in each experimental trial. Note that dots plotted above zero represent higher prey capture rate in a decorated web.

each prey order (Table 1). These results implied that detritus stabilimenta had no significant effect on prey capture rate.

Discussion

It has been reported that visual effects of webs such as visibility and reflectance property of threads change prey behavior, which affects foraging success consequently (Rypstra 1982; Craig 1990; Craig & Bernard 1990). Some visual effects work positively in foraging success. For example, *Nephila clavipes* improves foraging success by using different colored threads in response to different light environments (Craig et al. 1996), and silk stabilimenta attract prey by reflecting UV light (Craig & Bernard 1990; Watanabe 1999). Negative effects on foraging success were also reported; high visibility of webs with dense mesh promotes prey avoidance from the webs (Rypstra 1982). In *Cyclosa octotuberculata*, its detritus stabilimentum occupied large proportion of the web area: its length is sometimes 10 times larger than the spider body length, making up 60% of vertical web diameter (*personal observation*). I expected that detritus stabilimenta had a visual effect on foraging success, but the results did not support this expectation. Because the differences in prey capture rates between webs with and without a stabilimentum was very small, type 2 errors due to a small sample size seems to be small. Physiological condition of spiders such as hunger level is known to affect response to prey (Herbestein et al. 1998). Individual hunger level was not controlled in this experiment, but this is unlikely to affect the results because the rate of prey interception seems unaffected by spider behavior.

Table 1. Results of multiple regression analyses for explaining the difference in prey capture rate with and without detritus stabilimentum. Five independent variables (presence of detritus stabilimentum, capture area, mesh size, body length and light level) and a dependent variable (prey capture rate per 1 hour) were used. Analysis was conducted separately for all prey insects combined and each taxonomic group.

Dependent variable	Independent variable*	F	P	Statistical significance**
Total prey	body length	0.655	0.433	N.S.
Diptera	body length	1.947	0.186	N.S.
Hymenoptera	light level	2.023	0.179	N.S.
Hemiptera	capture area	5.018	0.043	N.S.
Others	mesh size, light level	0.743	0.496	N.S.

*: A variable or a combination of variables having the highest F value obtained from backward elimination methods.

**: Significance level adjusted by the sequential Bonferroni method.

Ultraviolet light (UV) is known to be one of the visual components that affect insect behavior. Threads constituting silk stabilimenta have a high UV reflectance property, which attracts prey insects (Craig & Bernard 1990). On the other hand, detritus stabilimenta consist of various materials including prey remains and plant materials (Nakahira 1957), hence UV reflectance property of detritus stabilimenta may differ from that of silk stabilimenta.

The present study rejected the hypothesis detritus stabilimenta affected prey capture rate. Edmunds (1974) suggested that detritus stabilimenta function as an antipredator device. To test this hypothesis, it is necessary to compare survivorship of spiders with and without detritus stabilimenta by manipulative field experiment. The methodology described here would be useful for this kind of research.

Acknowledgments

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References

Craig, C. L. 1990. Effects of background pattern on insect perception of webs spun by orb-weaving spiders. *Anim. Behav.*, 39: 135–144.

- Craig, C. L. & Bernard, G. D. 1990. Insect attraction to ultraviolet-reflecting spider webs and web decorations. *Ecology*, 71: 616–623.
- Craig, C. L., Weber, R. S. & Bernard, G. D. 1996. Evolution of predator-prey systems: Spider foraging plasticity in response to the visual ecology of prey. *American Naturalist*, 147: 205–229.
- Edmunds, M. 1974. *Defence in Animals*. Longman, Essex.
- Harvey, P. H. & Pagel, M. D. 1991. *The Comparative Method in Evolutionary Biology*. Oxford University Press, New York.
- Herbestein, M. E., Abernethy, K. E., Backhouse, K., Bradford, H., Crespigny, F. E., Luckock, P. R. & Elgar, M. A. 1998. The effect of feeding history on prey capture behaviour in the orb-web spider *Argiope keyserlingi* Karsch (Araneae: Araneidae). *Ethology*, 104: 565–571.
- Nakahira, K. 1957. Spiders and debris. *Atypus*, 14: 3–6. (In Japanese)
- Nakahira, K. 1965. Ecological function of stabilimentum. *Atypus*, 37: 1–45. (In Japanese)
- Rovner, J. S. 1976. Detritus stabilimenta on the webs of *Cyclosa turbinata* (Araneae, Araneidae). *J. Arachnol.*, 4: 215–216.
- Rypstra, A. L. 1982. Building a better insect trap; An experimental investigation of prey capture in a variety of spider webs. *Oecologia*, 52: 31–36.
- Sokal, R. R. & Rohlf, F. J. 1995. *Biometry* 3rd ed. Freeman, New York. 240 pp.
- Watanabe, T. 1999. Prey attraction as a possible function of the silk decoration of the uloborid spider *Octonoba sybotides*. *Behav. Ecol.*, 10: 607–611.

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Acta Arachnologica Vol. 52, No. 1 掲載論文の和文要旨

ゴミグモ (クモ目: コガネグモ科) のゴミリボンが餌捕獲に及ぼす影響 (pp. 1-3)

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本研究ではゴミグモ (*Cyclosa octotuberculata*) のゴミリボンが獲物の行動に影響を与え、餌捕獲数に影響を及ぼすという仮説を検証した。実験的にゴミリボンのある網と無い網を作成し、野外で餌捕獲数を比較したところ有意な差はなかった。またその他の要因を考慮にいれて重回帰分析を行ったが、餌捕獲数への影響はみとめられなかった。この結果よりゴミリボンが網上の大きな構造物にも関わらず獲物に対して視覚的效果をもたない可能性が考えられる。

札幌市近郊におけるザトウムシの季節消長と生態、およびエゾナミザトウムシとその近縁種についての分類学的ノート (pp. 5-24)

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札幌市近郊の3カ所(野幌, 円山, 北大構内)に生息するザトウムシ11種の季節消長と生態を調査した。ほとんどの種は年1化卵越冬の生活史を示したが、フタコブザトウムシ *Paraumbogrella pumilio* は年1化成体越冬、マキノブラシザトウムシ *Sabacon makinoi* では卵と幼体の両方での越冬が示唆された。四国に生息するザトウムシと比較すると、幼体越冬の種を欠くことが北海道産種の生活史の特徴である。卵越冬の種では、春季により早く孵化する種ほど幼体期間が長かった。また、卵越冬のほとんどの種で雌が雄よりも早く成体に達する傾向(雌先熟)がみられた。雌先熟は他のクモガタ綱や昆虫では非常に珍しいが、マザトウムシ上科 *Phalangioidea* のザトウムシでは一般的傾向と思われる。長い繁殖期間と雌の多数回交尾が一般的であることが雌先熟傾向を生み出しているのかもしれない。土壌性の3種(ブラシザトウムシ属 *Sabacon* 2種とフタコブザトウムシ *P. pumilio*) をのぞき、どの種も幼体初期には土壌リター中で過ごす。幼体期の途中から、草本層や樹幹へ日中の生息場所を移した。両生生殖の3種では性比は雄に偏る傾向がみられた。雌先熟とも関係して、性比は時間的にも変化した。7種の産卵数と10種の卵サイズのデータを示した。ブラシザトウムシ科の2種の卵のうを初めて記録した。さらに、学名が未決定であったエゾナミザトウムシに対して *Nelima suzukii* の名称を与え、ナミザトウムシ属の分類について若干の知見を付記した。

韓国及び日本産のケムリグモ属 (クモ目: ワシグモ科) 数種についての分類学的検討 (pp. 25-30)

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ケムリグモ属 *Zelotes* の数種について分類学的検討の結果を報告した。韓国で記載されたミカドケムリグモ *Z. kimwha* Paik 1986 と *Z. tintinnus* Paik 1986 については、同一地点から採集された雌雄の標本を検討した結果、後者を前者の新参異名とした。北海道に分布するコブシケムリグモ *Z. hayashii* Kamura 1987 とピフカケムリグモ *Z. bifukaensis* Kamura 2000 については、前者の雌雄及び後者の雄のみが知られており、後者の雌は未知であったが、新たな標本を検討した結果、従来コブシケムリグモの雌とみなされていたものは正しくはピフカケムリグモの雌であることが判明し、同時に、真のコブシケムリグモの雌も見出された。沖縄産のリュウキュウケムリグモ *Z. ryukyuensis* Kamura 1999 とツヅラケムリグモ *Z. flexuosus* Kamura 1999 については、前者の雌雄及び後者の雌のみが知られており、後者の雄は未知であったが、沖縄島における再調査の結果、これら2種の雄の触肢の構造は互いに極めてよく似ており、リュウキュウケムリグモの雄とみなされていたものの中にツヅラケムリグモの雄が混じっていたことが判明した。

東京都青梅市の山林から発見されたササラダニ類 (イカダニ科) の1新種 (pp. 31-33)

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青梅市の北部に広がる黒沢川沿いのコナラを主とする林の林床の倒木の樹皮から、イカダニ科に属するササラダニ類の未記載種が見出されたので *Dolicheremaeus ohmensis* オウメイイカダニと命名して記載した。イカダニ科の多くの種では後体部前縁に2対の瘤状突起があるが、本種を含めて6種では、その突起が1対しかない。その中で本種は胴感毛の柄が短く先端部が強く膨らむこと、背毛が短いものと著しく長いものの2群に分かれることなどによって、既知の5種から区別される。

日本産キシダグモ科の2新種および2新記録種 (pp. 35-42)

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日本産キシダグモ科の2新種, *Dolomedes orion* n. sp. オオハシリグモ (新称) と *Dolomedes zatsun* n. sp. ササキハシリグモ (新称) を記載し, *Dolomedes horishanus* Kishida 1936 ヘリジロハシリグモと *Pisaura bicornus* Zhang & Song 1992 サイホウキシダグモ (新称) の2種を日本から新たに記録し, 再記載した。また, *Dolomedes yawatai* Ono 2002 イシガキアオグロハシリグモを西表島から新たに記録した。台湾から知られていた *Dolomedes mizhoanus* Kishida 1936 はヘリジロハシリグモの新参シノニムである。